Analysis of Psycho-Physiological and Psychomotor Ability in Pace and Spin Bowlers in Cricket

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Abstract

	extbf{Background:} Sport is covered with the messed up dreams of the individuals who faltered when they generally should have been in charge of themselves and to be centered around the job needing to be done. The study's main objective was to find out the difference between the psychological, physiological, and various psychomotor variables of pace and spin bowlers. To the best of the knowledge, none of the studies has dealt with the psycho-physiological, psychomotor, and psychological variables of bowlers in cricket. 

	extbf{Methods:} In psychological variables, it was emotional expressivity & state and trait anxiety scale; in physiological variables, it was heart rate & skin conductance; in psychomotor variables, it was reaction test, sustained attention, time movement anticipation, & sensomotor coordination (Vienna Test System,) and the bowling performance. 

	extbf{Results:} The studies results show that there was a significant difference in the three physiological variables of skin conductance, bowling performance, and heart rate; and the scores showed an upward trend for both the fast bowlers and spinners while facing three different kinds of batsmen(attacking, balance and defensive based on strike rate) while it was found that the mean scores of spinners were higher than pacers while facing attacking batsmen and balanced batsmen. In the psychomotor variables, only the Mean Motor Time was found to have significant difference and the spin bowlers had a higher mean than the pace bowlers. While there was no significant difference between the psychological variables of state and trait anxiety and Berkley's expressivity.

	extbf{Conclusion:} This study may help coaches and trainees to train bowlers in the mental aspect as per the challenges of the game. When subjected to the simulated experimental protocol of super over, the spin bowlers compared to pace bowlers demonstrated more arousal while facing attacking batsmen followed by balanced and then defensive batsmen.

	extbf{Keywords:} Psycho-physiological, Psychomotor, Vienna test system, STAI, Berkley's expressivity Questionnaire, Cricket, Bowlers

How to cite this article: Mishra A, Acharya J, Bagchi A (2020): Analysis of psycho-physiological and psychomotor ability in pace and spin bowlers in cricket, Ann Trop Med & Public Health; 23(S17): SP231760. DOI: http://doi.org/10.36295/ASRO.2020.231760

1. Introduction:
Sport is covered with the messed up dreams of the individuals who faltered when they generally should have been in charge of themselves and to be centered around the job needing to be done	extsuperscript{(1)}. When elite cricketers and Olympians reflect on their success they tend to recall how nervous and emotional they were before a competition, but once the game or competition began they became immersed in the task and executed their well-trained skills with no disruptive signs of anxiety	extsuperscript{(2)}. Talking about anxiety, anxiety differs from fear in long-lasting and intending to be more undifferentiated than fear- as individuals could also be anxious about things that is not physically there or instantaneously seen. Although there are differences, anxiety is pretty similar to fear in several ways	extsuperscript{(3)}. The awareness of threats could be based on rational or irrational fears even though the difference involving these two is often unclear in daily living	extsuperscript{(4)}. Emotions are feelings we
experience (in and out of cricket) in response to an event, which determines our thoughts and behavior. Stuart Broad, the leading English speedster doing high knees before each spell of bowling to let go of any tension and increase blood flow and heart rate is a fine example of dealing with arousal\(^2\). Physiologically, sympathetic nervous system moderates the sentiments of arousal. Subsequently when we become excited, our cerebrum's reticular activating system activates the arrival of biochemical substances similar to epinephrine and norepinephrine to the circulatory system so that our body is stimulated fittingly for activity. Along these lines, anxiety can be recognized from arousal as follows. In spite of the fact that arousal includes undifferentiated bodily energy, arousal is an emotional name for a specific kind of arousal experience\(^3\). This view is supported in a model of arousal created by Gould et.al.\(^6\). In this model, cognitive anxiety is accepted to rise up on how arousal is interpreted. In this manner, anxiety can be viewed as negatively interpreted arousal. This view brings up the issue of individual differences in arousal interpretation.\(^4\).

Tiger woods has publicized that "the challenge is hitting good golf shots when you have to... to do it when the nerves are fluttering, the heart-pounding, the palms sweating... that's the thrill"\(^7\). Cricket is an emotional experience and players will experience both positive and negative emotions. Positive emotions (e.g., happiness) can bring about helpful performance gains, while negative emotions (e.g., anger) have a debilitating effect\(^2\). The 5-10 seconds period immediately prior to the task execution is one key components of performance in motor tasks which are skilled. In the "preparatory" period the final modifications are made to their arousal/attentional sets. During attentional processing several seconds prior to an expected event there is an expectant cardiac deceleration. On the other hand, Obrist\(^8\) claimed that when motor activity is reduced there was an indirect effect while there was not any HR changes directly attributable to attention. Hence it was recommended that for measuring arousal both HR and SCL are not good indicators, so they should be studied separately\(^9\), but according to Tremayne and Barry suggested SCL as an indicator for arousal, while HR was considered as an index for vigilance and have studied these two functions during the skilled performance of pistol shooters. In psychophysiology, SCL being regarded as the "gold standard" has a longer history for measuring arousal\(^10\).

The same physical symptoms of arousal can accompany good performance in a flow state or poor performance when an athlete chokes. The difference lies in how an athlete interprets the arousal\(^11\).

With the 2019 world cup cricket being decided with the help of a superover, this is a small attempt by the researcher to study what goes on physiologically, psychologically and psychomotor wise when the two types of bowlers both pace and spin bowlers are called upon to bowl when the trophy or the championship or even the match result is in line while facing different types of batsmen. The purpose of the study was to find out the difference between the psychological, physiological, and various psychomotor variables of pace and spin bowlers during the experimental setup of super over in cricket.

2. Material And Methods:

2.1. Selection of the Subjects: For this study, the bowlers were categorized into pace bowlers and spinners based on the type of bowling they did. The sampling technique used was conveniently purposive sampling. 30 players of the university level of cricket were selected, of which 15 were pace bowlers and 15 were spinners in each category. The batsmen were selected from the national level and were differentiated into three groups attacking, balanced and defensive based on strike rate. Subjects provided written, voluntary, and informed consent before participation.

2.2. Selection of the Variables: Based on the review of literature, expert opinion, facilities & instrument availability, and researcher's understanding of the problem various psychophysiological and psychomotor variables were selected.

Table 1. Table showing the variables and criterion measures adapted in the study

<table>
<thead>
<tr>
<th>Variables used in the study</th>
<th>Psychological variables</th>
<th>Physiological</th>
<th>Psychomotor</th>
<th>Performance</th>
</tr>
</thead>
</table>

### Criterion Measures

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Variables</th>
<th>Test</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Emotional Expressivity: Negative Emotional Facets Positive Emotional Facets Impulse Strength</td>
<td>Berkeley Expressivity Questionnaire</td>
<td>Scores</td>
</tr>
<tr>
<td>2</td>
<td>State And Trait Anxiety</td>
<td>State-Trait Anxiety Inventory (STAI Form Y-1 and Y-2)</td>
<td>Scores</td>
</tr>
<tr>
<td>3</td>
<td>Skin Conductance</td>
<td>Biograph Infiniti (Sc-flex/Pro Sensor )</td>
<td>Siemens</td>
</tr>
<tr>
<td>4</td>
<td>Heart Rate</td>
<td>Suunto T-6 Watch</td>
<td>Beats/Minute</td>
</tr>
<tr>
<td>6</td>
<td>Reaction Time: Mean Motor Time Mean Reaction Time</td>
<td>Vienna Test System</td>
<td>Msec</td>
</tr>
<tr>
<td>7</td>
<td>Mean Standard Deviation Sensorimotor Coordination</td>
<td>Vienna Test System</td>
<td>Pixels</td>
</tr>
<tr>
<td>8</td>
<td>Mean Standard Deviation Horizontal Sensorimotor Coordination</td>
<td>Vienna Test System</td>
<td>Pixels</td>
</tr>
<tr>
<td>9</td>
<td>Mean Standard Deviation Vertical Sensorimotor Coordination</td>
<td>Vienna Test System</td>
<td>Pixels</td>
</tr>
<tr>
<td>10</td>
<td>Time in Ideal Range Sensorimotor Coordination</td>
<td>Vienna Test System</td>
<td>Scores</td>
</tr>
<tr>
<td>11</td>
<td>Scores Correct Sustained Attention</td>
<td>Vienna Test System</td>
<td>Scores</td>
</tr>
<tr>
<td>12</td>
<td>Mean Time Correct Sustained Attention</td>
<td>Vienna Test System</td>
<td>Time</td>
</tr>
<tr>
<td>13</td>
<td>Visual Pursuit</td>
<td>Vienna Test System</td>
<td>Scores</td>
</tr>
<tr>
<td>14</td>
<td>Bowling Performance</td>
<td>Three Judges Criteria</td>
<td>Scores</td>
</tr>
</tbody>
</table>

**2.3. Data Collection Technique:** The bowlers both pace bowlers and spin bowlers were made to face three different types of batsmen attacking, balanced, and defensive on different days. The bowlers were asked to fill up questionnaires; the STAI Form Y1 & Y2 and Berkeley Expressivity Questionnaire were completed by the participant. The electrodes were fixed on the bowlers and the bowlers were given 10 minutes to get used to the electrodes to warm up and become familiar with the exercise, one over was bowled consisting of 6 deliveries (super over). The details of the super over and how the data was collected is illustrated further in detail in figure 1 and figure 2. On the first day, the bowler’s psycho-physiological data was collected while facing attacking batsmen, on the second day the bowler’s psycho-physiological data was collected while facing the balanced type of batsmen and on the third day the bowler’s psycho-physiological data was collected while facing the defensive type of batsmen. Then the pre-delivery physiological data was collected before bowling to one type of batsman and then at the end of the over, once again the data was collected. The procedure was repeated until the data was collected on bowlers facing batsmen of different playing styles at the same performance levels while the three judges evaluated the bowling performance during the time. The subject’s heart rate was measured monitored using a Suunto t6 heart rate monitor wrist device and associated chest sensor belt. After the psycho-physiological data was collected then the subjects were made to take the psychomotor tests using the Vienna Test System (VTS) and the data was recorded.
Figure 1. Illustration depicting the timeline adopted in the study

X - TIME TAKEN FOR FIELD SET UP AND TO GET READY FOR BOWLING
O - DATA COLLECTION THROUGH FILLING UP OF QUESTIONNAIRE OF STATE AND TRAIT ANXIETY AND EMOTIONAL EXPRESSIVITY
D - DATA COLLECTION OF HEART RATE, SKIN CONDUCTANCE AND BOWLING PERFORMANCE

Figure 2. Illustration depicting the experimental protocol adopted in the study

2.4. **Statistical Technique:** The descriptive analysis includes the data obtained on the pace and spin bowlers about their psychological, physiological, psychomotor, and bowling performance responses while facing three different types of batsmen (attacking, balanced and defensive). The descriptive analysis was done by computing mean, standard deviation, and coefficient of variation of all the data.

For the physiological variables of skin conductance, heart rate, and bowling performance, the analysis of data was done using repeated measure analysis of variance (MANOVA), to address the research questions.

For the psychomotor variables, an independent t-test was used for the variables for the comparison between the spin and the pace bowlers. The SPSS-20 software was used for analysis.

### 3. Results and Discussion:

#### Figure 3. Illustration Descriptive statistics of Psychomotor Variables of Pace and Spin Bowlers

#### Figure 4. Descriptive statistics of STAI and Berkley's Emotional Expressivity of Pace and Spin Bowlers while facing different batsmen
One of the conditions for using the two-sample t-ratio for unrelated groups is that the variance of the two groups must be equal. To test the equality of variances, Levene’s test was used. It was found that F-value is 0.14 which is insignificant as the p-value is 0.71 which is more than 0.05. Thus, the null hypothesis of equality of variances was accepted and was concluded that the variances of the groups were equal.

It was seen that the value of the t-statistic for (mean motor time) MMT_RT is 1.80. This t-value is significant as the calculated value (1.80) is more than the tabulated value (1.701) at 28 degrees of freedom.

In the variable of skin conductance, post hoc analysis with a Bonferroni adjustment was applied for comparing the means of groups. It can be seen that the mean difference between the attacking batsmen and balanced batsmen (1.307), between the attacking batsmen and defensive batsmen (3.200) and balanced and defensive (1.893) is significant as the p-value (0.00) for this mean difference is less than 0.05.

It was seen that the mean skin conductance of the spin and pace bowlers while facing attacking batsmen was more than that while facing balanced batsmen and defensive batsmen. Thus, it may be concluded that the skin conductance levels while facing attacking batsmen were higher followed by that balanced and that of defensive batsmen.

In the variable of heart rate, Post hoc analysis with a Bonferroni adjustment was applied for comparing the means of groups. It was seen that the mean difference between the attacking batsmen and balanced batsmen (1.228), between the attacking batsmen and defensive batsmen (2.594) and balanced and defensive (1.366) is significant as the p-value (0.00) for this mean difference is less than 0.05.

It was seen that the mean heart rate of the spin bowlers while facing attacking batsmen was more than that while facing balanced batsmen and defensive batsmen. Thus, it may be concluded that the heart rate while facing attacking batsmen was higher followed by that balanced and that of defensive batsmen.

Post hoc analysis with a Bonferroni adjustment was applied for comparing the means of groups of batsmen while facing the pace bowlers.

It was seen that the mean difference between the attacking batsmen and balanced batsmen (1.228), between the attacking batsmen and defensive batsmen (2.594) and balanced and defensive (1.366) was significant as the p-value (0.00) for this mean difference is less than 0.05.

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It was seen that the mean heart rate of the pace bowlers while facing attacking batsmen was more than that while facing balanced batsmen and defensive batsmen. Thus, it may be concluded that the heart rate levels while facing attacking batsmen are higher followed by that balanced and that of defensive batsmen.

In the bowling performance variable, for the pairwise comparisons of the data for bowling performance; Post hoc analysis with a Bonferroni adjustment was applied for comparing the means of groups.

It was seen that the mean difference between the attacking batsmen and balanced batsmen (0.428), between the attacking batsmen and defensive batsmen (1.594) and balanced and defensive (1.166) is significant as the p-value (0.00) for this mean difference is less than 0.05.

Thus it was concluded that the bowling performance of the bowlers was higher for attacking batsmen, followed by balanced batsmen and then followed by defensive batsmen. But there was no significant difference between the bowler’s scores while they faced attacking and balanced batsmen.

Multivariate analysis of variance for repeated measures was applied to the data collected on the sub-variables of Berkeley’s Emotional Expressivity and the results are thus represented.

The main purpose of the repeated measures mixed MANOVA is to test the interaction effect. The Wilk’s lambda was considered to be more robust and not severely affected by the violations of assumption. The Wilk’s lambda value (.724) for the interaction effect of Bowlers was found to be insignificant with a p-value of .005 (which is more than the required p-value of 0.05).

As the Interaction effect of the batsmen and bowlers was found to have an insignificant effect on the dependent variables, hence the main effects of the bowlers (between-subjects factor) was seen which was also was found to be insignificant as the Wilk's lambda value (.367) for the main effect of bowlers was found to be insignificant with a p-value of .005 (which is more than the required p-value of 0.05). Similarly, for the batsmen (within-subjects factor) no significant difference was found as the Wilk's lambda value (.885) for the main effect of batsmen was found to be insignificant with a p-value of .005 (which is more than the required p-value of 0.05).

Thus it was concluded that the bowling performance of the bowlers was higher for attacking batsmen, followed by balanced batsmen and then followed by defensive batsmen. But there was no significant difference between the bowler’s scores while they faced attacking and balanced batsmen.

Multivariate analysis of variance for repeated measures was applied to the data collected on the sub-variables of Berkeley’s Emotional Expressivity and the results are thus represented. The Wilk's lambda value (.016) for the interaction effect of Batsmen and Bowlers was found to be significant with a p-value of .005 (which is much lesser than the required p-value of 0.05). As the interaction effect of the batsmen and bowlers was found to have a significant effect on the dependent variables, a further analysis was done to determine the simple effects of the within and the between-subjects factor, and the results are displayed in next table.

The Wilk's lambda value (.302) for the main effect of Bowlers was found to be significant with a p-value of .005 (which is more than the required p-value of 0.05). As the main effect of intensity was found to have an insignificant effect on the dependent variables, a further analysis was not done to determine the main effect of intensity and the results are displayed in the next table.

The Wilk's lambda value (.000) for the main effect of Batsmen was found to be significant with a p-value of .005 (which is much lesser than the required p-value of 0.05). As the main effect of intensity was found to have a significant effect on the dependent variables, further analysis was done to determine the main effect of intensity and the results are displayed in tables.

One of the more critical components of skilled motor performance is the 5-10 seconds period immediately before the execution of the task. It is amid this "preparatory" period that performers make final adjustments in their arousal/attentional sets. Expectant cardiac deceleration has been observed to develop several seconds immediately before an expected event requiring attentional processing. On the other hand, Obrist(8) stated that HR changes are not directly attributable to attention but rather an indirect effect of reduction in motor activity. It was suggested that HR and SCL are not both indices for arousal measurement and must be studied separately(9), but Tremayne and Barry regarded the SCL as an index of arousal and the HR as an index of vigilance.
and have studied these two functions during the skilled performance of pistol shooters. SCL as the “gold standard” in the measurement of arousal has a long history in psychophysiology(10).

The 5-10 seconds period immediately before the execution of the task is one of the most vital components of performance in skilled motor tasks. In the "preparatory" period the final modifications are made to their arousal/attentional sets. During attentional processing several seconds prior to an expected event there is an expectant cardiac deceleration. On the other hand, Obrist(8) claimed that when motor activity is reduced there was an indirect effect while there was not any HR changes directly attributable to attention. Hence it was recommended that for measuring arousal both HR and SCL are not good indicators, so they should be studied separately(9), but according to Tremayne and Barry suggested SCL as an indicator for arousal, while HR was considered as an index for vigilance and have studied these two functions during the skilled performance of pistol shooters. In psychophysiology, SCL being regarded as the “gold standard” has a longer history for measuring arousal(10).

There is abundant literature suggesting negatively-valenced (i.e., intrinsic evasiveness of events, or situations) emotions like anxiety, etc rather than positively-valenced (i.e., intrinsic attractiveness of events) like satisfaction, etc play crucial roles(12). This finding has two sides to the same coin, one being obvious and other being obscure. There are a lot of emotions that one's quality of individual sport performance depends upon hence the machinery of their emotions should be dismantled so that performers can give their very best every time where the emotions are negatively valenced equally, but it's still unclear and vague what are the emotions experienced during peak performances(13) and flow experiences(14,15) and these emotions are rarely investigated although these emotions are not always positively valenced.

Although positively-valenced emotions e.g., enjoyment, are always linked with exceptional performances in sport, hence it becomes even more obligatory and educational for establishing their exact characteristics and utility. Besides, positive and negative emotions are not alone, people experience myriad of emotions at the same time, even if they are contrary in make-up and in particular if they are moderating in intensity(16,17). This understanding has in fact propelled researchers to focus not only on stress and its coping but also specifically towards measuring basic emotions(the intensity and frequency), as well as positive emotions(18,19). These current changes in stress and coping mean that we must renew the researches on sports emotions to precisely broaden our understanding the role of emotions within sports performance.

In the industrial and military frameworks, how performance is effected under heat stress has been studied(20,21). A minority of studies have particularly emphasized on the nuisances caused due to heat stress in sports, particularly in areas of cognition. However, the climate plays a major stressor in numerous sports events, principally in cricket which is also an outdoor activity. In Sports conditions are characterized by synchronized high demands placed on both the individual's physiological and cognitive assets. Normally, stressors effect on the individual's physiological and cognitive resources have been studied independently. As there are important mutual influences of physiological and cognitive processes(22), hence necessarily a more all-inclusive approach is needed. The main approach in recent times has been to study the effects of exercise on cognitive processes, especially reaction time tasks(23,24,25). The results clearly showed that there was a decrease of simple reaction time, but increase in the reaction time, as studied by team and combat sports experts. These divergent effects seemed linked to multifaceted relations among the precise influence of exercise on some processes of cognition(26), and a dissipation of mental effort while under exertion(27).

Electrodermal levels for the expert shooters during pre-shooting were lower for the best shots when compared with worst shots, and pre-shot cardiac deceleration and its duration was longer and more orderly for best as compared with worst shots(10). Study on psycho-physiological correlations with gameplay experience dimensions on First-Person Shooter (FPS) games (Prey, Doom 3, and Bioshock all major commercial games) pointed out that HR, as a determiner for arousal, and also an excellent correlator with PX(self-report measure), both positively or negatively(28). A study
conducted on physiological patterning of short badminton serve a psycho-physiological perspective to vigilance and arousal; immediately before action, elite shuttlers demonstrated a non-significant reduction in SCL and a significant decrement in HR followed by a rebound increase\(^{(29)}\).

4. Conclusion:

The objective of the study was to analyze the psycho-physiological, and psychomotor abilities in pace and spin bowlers in cricket during the simulated experimental setup of a super over in cricket. It was found that among the psychomotor variables there was a significant difference in between mean motor time (reaction time) of the spin bowlers were found to be greater than fast bowlers. In the physiological variables, there was a significant difference in both the variables of skin conductance and heart rate. Also, the bowling performance variable was found to be significant. In all the three variables (HR, SC, and Bowling performance), a similar trend was found which was higher for spin bowlers as compared to pace bowlers with the scores being higher while facing the attacking, followed by balanced and defensive batsmen. While the psychological variables of both state-trait anxiety and Berkley expressivity questionnaire were not found to be significant. This study will be aiding in creating schedules for athletes especially cricketers in dealing with the lacunas that were observed.

**Ethical Clearance:** Not applicable

**Source of Funding:** Self-funded

**Conflict of Interest:** There is no conflict of interest among the authors

References